Irregularities in Replacement Imagery

INFORMATION SHEET
July 2006

What is Replacement Imagery?

Replacement imagery, also known as image base replacement in the USDA Farm Service Agency, is imagery that takes the place of another imagery dataset covering the same location on the earth's surface. Replacement of imagery may be due to acquisition of imagery that is newer, more accurate spatially, contains more information, or due to FSA program policy.

Why are there irregularities in replacement imagery from one year to the next?

Virtually always, when new imagery is acquired, it does not match up spatially in every location with past imagery. It can be infuriating to digitize based on good imagery, and then feel as if you need to go back and redigitize based on newer imagery that was supposed to meet the standards of the imagery you were just using.

This is the nature of imagery acquisition. *No* imagery will look alike or be in the same exact location on the face of the earth uniformly, as compared to any other imagery dataset of the same location on earth.

The only way two images could be exactly the same is if imagery was shot from the same exact location above the earth's surface at the same time of the day and same day of the year, from the same camera calibrated in the same manner, during the same atmospheric conditions, using the same orthorectification process and the same Aerial Triangulation (AT) solution, the same ground control, and the same Digital Elevation Model (DEM). Even then the two images would likely not look the same. Many of these variables are discussed later on.

As with any photography, aerial photography is part art and part science. No two portraits of the same person look exactly the same. Likewise, no two portraits of the earth's surface look the same.

What is Parallax?

Parallax is a distortion caused by an aerial image being shot from not exactly above a particular point on the ground (an angle). More simply, parallax is the apparent shift of an object against a background due to a change in the observer's position; the apparent motion of an object against a distant background because of a perspective shift.

For example, you are driving in the car and you see an oak tree in a farmer's field. The tree looks to be directly in front of the farmhouse. As you get closer, the tree no longer seems to be in front of the farmhouse, rather in front of the barn. Finally you drive past the tree and look back. It no longer blocks the farmer's property from view; it now blocks your view of another farmer's land you passed a mile back.

This same phenomenon occurs with aerial photography, and more so with tall objects such as trees or buildings. One year the tall oak tree blocks the farmhouse on the imagery, while the next year it blocks part of the field, which could lead someone make the assessment that useable acreage for farming decreased, and could result in edits to the Common Land Unit (CLU).

What is Sun Angle?

The angle of the sun is a direct result of latitude, time of day and year. The sun allows shadows to be cast from things at a higher elevation onto things at a lower elevation. When shadows are cast, it can be difficult to "see" what is in the shadow. The area within a shadow is (in natural color photography) an area where less data is acquired; little light is reflected from within shadow.

Shadows can help identify things, but can also be detrimental. Shadows cast by large trees, clouds, buildings, mountains, hills, tops of canyons, etc., all can hide data that may be required for decision making.

For example, one year the sun was just about over head, and the trees next to a CLU cast almost no shadow. The next year the sun is a bit lower in the sky, and the trees seem to have enlarged in size, seemingly reducing the acreage of the CLU, and making CLU linework look less than perfect. If the shadow is not recognized as a shadow in an image, rather part of the tree, an

incorrect determination on acreage, and subsequent change to CLU could occur.

What is a Digital Elevation Model (DEM)?

DEMs are digital files consisting of optimal arrays of point elevations, sampled at equally spaced intervals. DEMs are used to simulate elevations when creating digital orthorectified photo products, or for numerous other purposes when analysis of elevation is important.

The accuracy of DEM data depends on the source and resolution of the data samples. DEM accuracy is derived by comparing interpolated elevations in the DEM with map location elevations. Then a root-mean-square error (RMSE) can be computed. RMSE is a measure of how closely a data set matches the represented real world elevations.

Although the standard used for many aerial photography acquisition projects is the National Elevation Dataset (NED) or better DEM source, there are thousands of different DEMs available. All of these DEMs vary in number of points and accuracy. Unless the exact same DEM is used, there will be differences in the resulting aerial photography product.

What is orthorectification?

Orthorectification is the term for the process of removing sources of distortion from an image and correcting aerial photography to the point where measurements of a feature on the photograph approximate ground measurements of the same feature.

Without orthorectification, one would not be able to make measurements of distances, positions, or areas from aerial photography. Orthorectification tries to remove distortions created by the 3 dimensional nature of the earth projected into the 2 dimensional world.

Terrain distortion can be removed by rectifying imagery using a DEM and control points. The DEM is used to note mathematical relationships between real world topography and the aerial image. These relationships are defined and displacement inherent in the image removed by warping the image so that distance and area are uniform in relation to real world.

What is Aerial Triangulation (AT) and control configuration?

Aerial Triangulation is an attempt to identify the exact x, y, z, location of an aircraft antenna during exposure. Ground control points are used to triangulate signals from the aircraft and help identify this exact location.

Factoring into AT is the specific location/distribution of the control points. Generally the more control points used and the closer to the aircraft, the more accurate the location identification. The closer to the real x, y, z, location the calculation is, the more accurate the resulting image can be to the true ground location.

There are other methods of pinpointing the exact location of an aircraft; airborne GPS and Internal Navigation System (INS) to name a few. Depending on the AT solution and control point configuration, various levels of known point accuracy will result. If methods and resulting accuracies differ year to year, imagery will look slightly different from one year to the next.

What is the difference between absolute and relative control?

Horizontal and vertical accuracy of an image when compared to another image is considered to be relative accuracy. The two images could be a hundred miles from where they actually reside on the earth's surface, and still be accurate relative to each other.

With absolute accuracy, an image is not compared to another image; rather it is compared to where the data on the image really exists on the earth's surface, usually based on a network of control points.

APFO presently uses relative accuracy for NAIP, comparing new imagery to base imagery. APFO is investigating moving to absolute accuracy methods.

What does all this mean to the farmer?

Drawing CLU based on imagery is not an exact science. Acreage measurements may change slightly when newer imagery is used. However, acreage should not change drastically due to replacement imagery, unless there was an actual change of land use on the earth's surface, such as a new road cut or building on cropland.

Measurements taken from imagery can be extremely accurate and it is a huge time saver; however, the *most* accurate measurement of acreage still relies on field surveys and GPS.

Who do I contact for more information?

1. For sales information, contact USDA-FSA-APFO at 2222 W 2300 S, Salt Lake City UT, 84119-2020, call 801-975-3503, or visit www.apfo.usda.gov.
2. If you have general questions about replacement imagery contact GIS Specialist, David Davis, at 801-975-3500 X278, or GIS Specialist, Brian Vanderbilt, at X240.